NOAA SECTORAL APPLICATIONS RESEARCH PROGRAM (SARP)
PROJECT ANNUAL REPORT (DRAFT)

PROJECT TITLE

Use of Intra-seasonal and Seasonal Forecasts to Reduce Risk in Regional Public Water Supply Management

INVESTIGATORS

Christopher J. Martinez (Lead Investigator)
Department of Agricultural and Biological Engineering
University of Florida
PO Box 110570
Gainesville, FL 32611-0570
(352) 392-1864 x279
chrisjm@ufl.edu

Gregory A. Kiker
Department of Agricultural and Biological Engineering
University of Florida
PO Box 110570
Gainesville, FL 32611-0570
(352) 392-1864 x291
gkiker@ufl.edu

Wendy D. Graham
Water Institute & Department of Agricultural and Biological Engineering
University of Florida
PO Box 116601
Gainesville, FL 32611-6601
(352) 392-5893 x2113
wgraham@ufl.edu

James W. Jones
Department of Agricultural and Biological Engineering
University of Florida
PO Box 110570
Gainesville, FL 32611-0570
(352) 392-1864 x289
jimj@ufl.edu

Mark A. Newman
Florida Water Resources Research Center
University of Florida
PO Box 116580
Gainesville, FL 32611-6580
(352) 392-9537 x1518
markn@ufl.edu

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I. PRELIMINARY MATERIALS

A Project Abstract

Florida's economic and social development over the past several decades has been fueled by its climate and abundant water resources. Increased population, rapid urban development, large agricultural water demands, and the need to protect natural resources, however, have led to conflicts between urban, agricultural, industrial, and natural system water users. Freshwater withdrawals in Florida are expected to grow from approximately 8.2 billion gallons per day (bgd) in 2000 to more than 9.3 bgd in 2020 in order to meet the needs of a population that is expected to increase from 16 to 22 million. Weather and climate variability has a major influence on demand and availability of water. Recent advances in short- and medium-range forecasts, and statistical downscaling techniques, indicate that these forecasts could be used to help water resource managers provide a more reliable, environmentally-sound supply of water. Although there is strong interest by water resource managers in the state, there is also considerable uncertainty in the risks of incorporating forecasts into their decision making processes. Questions by water managers include both how to replace historical information with forecasts as well as what new exposures to risk are possible in embracing forecast-based information.

The aim of this proposed project is to characterize the value, uncertainties and risks associated with the use of probabilistic precipitation forecasts for water management decisions. Southwest Florida, which includes the heavily populated Tampa Bay area, arguably has the most intense competition for water resources among urban, agricultural and ecological users. The major water resource decision makers in this area are Tampa Bay Water, the largest public water supplier in the region, and the Southwest Florida Water Management District (SWFWMD), which has the responsibility of issuing permits to users of surface and aquifer water sources. Two objectives will guide our research: 1) Develop and implement a prototype that uses weekly probabilistic forecasts with a 1-month forecast horizon in Tampa Bay Water's processes of forecasting demand and making source water allocation decisions, and 2) Quantify the uncertainty, reliability, and risk associated with using probabilistic forecasts in Tampa Bay Water's decision making. The first objective will focus on a 1-week to 1-month operational time-scale. The second objective will focus on both a) the operational time-scale, and b) a 1 to 24 month planning time-scale (and will complement the 1 to 24 month probabilistic precipitation forecasts that we a currently developing for Tampa Bay Water). Tampa Bay Water makes decisions on a weekly basis regarding how to meet their customers' water demand by rotating and apportioning among existing sources to minimize cost and environmental impacts while maximizing reliability. They have expressed strong interest in forecast use, but want to understand the risks of doing so. We will use analog techniques and Model Output Statistics (MOS) to incorporate short- and medium-range probabilistic forecasts into the decision models used by Tampa Bay Water and estimate risks and costs relative to using mean climate inputs in their decision process. Results of this research will be communicated to decision-makers and stakeholders using mechanisms that they routinely use, and we will summarize results on AgroClimate.org, the web-based climate information and decision support system developed by the Southeast Climate Consortium.

B Objective of Research Project

The goal of this project is to develop information needed by a public water supplier in a large urban area in Southwest Florida. Specifically, we aim to characterize the value, uncertainties and risks associated with the use of probabilistic precipitation forecasts for decisions on water allocations. The research will involve decision makers throughout the project and build on the operational and planning time-scale decision processes already in place in Tampa Bay Water, the major public water supplier in that area, and contribute to improved regional water management. The prototype methodology that incorporates the use of precipitation forecasts will be made available to Tampa Bay Water for its own evaluation and use. Toward this goal we have established the following two objectives: 1) Develop and implement a prototype methodology for incorporating 1-week to 1-month forecasts into Tampa Bay Water's processes of forecasting water demand and making source allocation decisions in Southwest Florida; and 2) Implement a comparative decision/risk analysis on Tampa Bay Water decision algorithms using historical- and forecast-based climate information for both short-term (1-week to 1-month) and medium-term (1-month to 24-month) time frames.

This project has two main objectives: 1) Develop and implement a prototype methodology for incorporating precipitation forecasts into Tampa Bay Water's decision making processes, and 2) Implement a comparative decision/risk analysis on Tampa Bay Water decision algorithms using historical- and forecast-based climate information.

For objective 1) we will focus on developing precipitation forecasts for the short-term operational interval (1-week to 1-month) and examine how reliability can be improved, or risk can be reduced, by incorporating precipitation forecasts into the short-term operational models employed by Tampa Bay Water. One-week to 1-month forecasts for individual rain gauges will be generated using: a) the archive of 1-14 day retrospective forecasts (reforecasts) maintained by the ESRL/PSD using a static version of NCEP's global forecasting system (GFS) and blended with a climatological or ENSO-conditioned climatological forecast (weeks 3 and 4), and b) Similar available forecast products such as the reforecast archive of the NCEP Climate Forecast System (CFS). Post-processing of the reforecast datasets will be conducted using both analog and model output statistic (MOS) techniques. The skill of these forecasts will be evaluated relative to current practice by Tampa Bay Water (assuming average rainfall or persistence of recent rainfall). Forecasts showing greater skill than current practice will be integrated into the suite of hydrologic and demand forecast models used by Tampa Bay Water for operational (1-week to 1-month) decision making.

In objective 2) we will focus on scenarios for both the 1-week to 1-month short-term operational forecast time-scale and the 1 to 24 month planning time-scale. In close cooperation with Tampa Bay Water staff, we will pose alternative water management scenarios and utilize multi-criteria decision analysis (MCDA). The scenarios and MCDA methods will use selected stakeholder and manager value judgments to evaluate various scenarios (both simulated with and without using weather and climate forecasts) to quantify the uncertainty, risk, and potential increase in reliability that can be achieved by integrating forecasts into Tampa Bay Water's source rotation decision making.

The key beneficiaries of this work will be water utility managers who must make source rotation decisions to maximize system reliability while minimizing environmental impact. Our collaborator, Tampa Bay Water will benefit directly from this work. We anticipate our results to benefit other water managers in Florida and other states by using our work as a case study on implementing forecasts in water resource decision making and evaluating the uncertainty

C Approach (including methodological framework, models used, theory developed and tested, project monitoring and evaluation criteria) include a description of the key beneficiaries of the anticipated findings of this project (e.g., decision makers in a particular sector/level of government, researchers, private sector, science and resource management agencies)

D Description of any matching funds/activities used in this project

For this project we have taken advantage of our on-going relationship with Tampa Bay Water technical staff. The benefit we have received has been in the form of the time spent by technical staff at Tampa Bay Water on this project and a project funded directly by Tampa Bay Water to investigate and evaluate the skill of seasonal precipitation and hydrologic forecasts.

II. ACCOMPLISHMENTS

A. Brief discussion of project timeline and tasks accomplished. Include a discussion of data collected, models developed or augmented, fieldwork undertaken, or analysis and/or evaluation undertaken, workshops held, training or other capacity building activities implemented.

Objective 1:

- The GFS reforecast archive has been downloaded to University of Florida servers
- Direct analog precipitation forecasts using the GFS reforecast archive have been completed for several gauges in the Tampa Bay region
- Logistic regression precipitation forecasts using the GFS reforecast archive are in progress
- Evaluation of analog precipitation forecasts on short-term demand and streamflow forecasts using short-term models used by Tampa Bay Water is in progress
- Evaluation of the sensitivity of methodology used in the selection of direct analog forecasts is in progress
- Improvement in analog selection using multiple predictors is in progress
- Precipitation forecasts using the CFS reforecast archive is in progress

Objective 2:

- Our work with Tampa Bay Water has determined that their decision making process is not strictly defined, but rather one that is 'informed' by model results, recent experiences (both hydrological and political), and expert judgment. In response we have begun to develop models of the unique decision making process of Tampa Bay Water. The models under development include:
    - The Water Evaluation And Planning (WEAP) system model
    - A spreadsheet-based linear optimization model using assigned preferences in the allocation of source waters to demand. This spreadsheet model directly mimics the water year planning spreadsheet used by Tampa Bay Water staff
- The WEAP model will be used mainly as a simulation model where we will evaluate the performance and reliability of the current system of infrastructure and current withdrawal regulations using historical data
- The spreadsheet model will be used mainly to make monthly source allocation projections 12 months in advance

B. Summary of findings, including their potential or actual implications for efforts to develop applications, methods, and science-based decision support capacity/systems and to foster sustainable resource management and vulnerability reduction.

We have found the direct analog precipitation forecast procedure using the GFS reforecast dataset to show predictive skill at lead times up to four days into the future at certain times of year for weather stations in the Tampa Bay region. We expect this forecast skill for precipitation to translate to forecast skill of short-term demand and streamflow.

We have found that existing methods for the selection of analogs have had a component of subjectivity (e.g. the spatial scale used, the number of analogs used, etc). To address the uncertainty of the analog method we intend to conduct a global sensitivity and uncertainty analysis of the procedure.

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C. List of any reports, papers, publications or presentations arising from this project; please send any reprints of journal articles as they appear in the literature. Indicate whether a paper is formally reviewed and published.

Journal Manuscripts:

Hwang, S., Graham, W.D., Hernandez, J., Martinez, C.J., Jones, J.W. and A. Adams. Quantitative evaluation of dynamically downscaled MM5 precipitation predictions over the Tampa Bay region, Florida. Submitted to Journal of Hydrometeology.

Abstracts:

Hwang, S., Graham, W.D., Hernandez, J., Martinez, C.J. and J.W. Jones. Assessment of Mesoscale Dynamical Downscaling Model (MM5) for Regional Climate Simulation in the Tampa Bay region. Eos Trans. AGU, 90(52), Fall Meeting of the American Geophysical Union, San Francisco, CA, December 14 – 18, Fall Meet. Suppl. Abstract H33E-0917.

Presentations:

Breuer, N.E., Knox, P., Martinez, C.J., Srivastava, P., Stooksbury, D. and D. Zierden. Southeast Water Climate: science and stakeholder co-development of a decision support system to reduce climate risk in water management. Presented at the University of Florida Water Institute Symposium: Sustainable Water Resources: Complex Challenges, Integrated Solutions. Florida Challenges Global Solutions. Gainesville, Florida, February 24 – 25, 2010.

Risko, S.L. and C.J. Martinez. Long-range streamflow forecasts in the Tampa Bay region using ENSO. Presented at the University of Florida Water Institute Symposium: Sustainable Water Resources: Complex Challenges, Integrated Solutions. Florida Challenges Global Solutions. Gainesville, Florida, February 24 – 25, 2010.

Rooney, R.W. and C.J. Martinez. Comparison of statistical methods for downscaling 1-14 day weather forecasts in the Tampa Bay region using a reforecast data set. Presented at the University of Florida Water Institute Symposium: Sustainable Water Resources: Complex Challenges, Integrated Solutions. Florida Challenges Global Solutions. Gainesville, Florida, February 24 – 25, 2010.

Timilsena, J. and C.J. Martinez. Water management scenario analysis of the Tampa Bay Water system. Presented at the University of Florida Water Institute Symposium: Sustainable Water Resources: Complex Challenges, Integrated Solutions. Florida Challenges Global Solutions. Gainesville, Florida, February 24 – 25, 2010.

Ingram, K.T., Fraisse, C.W., Martinez, C.J., Jones, J.W., O'Brien, J.J., Christy, J.R., Hoogenboom, G., Srivastava, P. and D. Letson. Monitoring and forecasting drought in the Southeast USA: Projects of the Southeast Climate Consortium. Presented at the 90th American Meteorological Society Annual Meeting, 5th Symposium on Policy and Socio-economic Research. Atlanta, Georgia, January 17 – 21, 2010.

Risko, S.L. and C.J. Martinez. Long-range streamflow forecasts in the Tampa Bay region using ENSO. Presented at the Southeast Climate Consortium Fall Planning Meeting. Gainesville, Florida, November 16 – 18, 2009.

Rooney, R.W. and C.J. Martinez. Evaluation of precipitation forecast analogs in the Tampa Bay region. Presented at the Southeast Climate Consortium Fall Planning Meeting. Gainesville, Florida, November 16 – 18, 2009.

Timilsena, J. and C.J. Martinez. Water management scenario analysis of the Tampa Bay Water system. Presented at the Southeast Climate Consortium Fall Planning Meeting. Gainesville, Florida, November 16 – 18, 2009.

Hwang, S., Graham, W.D., Hernandez, J., Martinez, C.J. and J.W. Jones. Evaluation of dynamical downscaling model for regional climate forecast: case study for the Tampa bay region. Presented at the American Society of Agricultural and Biological Engineers Annual International Meeting, Reno, Nevada, June 21 – 24, 2009.

Risko, S.L. and C.J. Martinez. Incorporating large-scale climate information in streamflow forecasts for the Tampa Bay region. Presented at the Florida Section of the American Society of Agricultural and Biological Engineers Annual Conference, Daytona Beach, Florida, June 10 – 13, 2009.

Rooney, R.W. and C.J. Martinez. Assessment of precipitation forecast analogs in the Tampa Bay region. Presented at the Florida Section of the American Society of Agricultural and Biological Engineers Annual Conference, Daytona Beach, Florida, June 10 – 13, 2009.

Risko, S.L. and C.J. Martinez. Incorporating large-scale climate information in streamflow forecasts for the Tampa Bay region. Presented at the Southeast Climate Consortium Program Review. Griffin, Georgia, May 5 – 7, 2009.

Rooney, R.W. and C.J. Martinez. Assessment of precipitation forecast analogs in the Tampa Bay region. Presented at the Southeast Climate Consortium Program Review. Griffin, Georgia, May 5 – 7, 2009.

D. Discussion of any significant deviations from proposed workplan (e.g., shift in priorities following consultation with program manager, delayed fieldwork due to late arrival of funds, obstacles encountered during the course of the project that have impacted outcome delivery).

None

E. Where appropriate, describe the climate information products and forecasts considered in your project (both NOAA and non-NOAA); identify any specific feedback on the NOAA products that might be helpful for improvement. (bulleted response)

- 1-14 day GFS reforecast archive of the ESRL/PSD (http://www.esrl.noaa.gov/psd/forecasts/reforecast/)
- The NCEP CFS reforecast archive (http://cfs.ncep.noaa.gov/)
- Oceanic Niño Index (ONI) and ENSO phase definitions

III. GRAPHICS: PLEASE INCLUDE THE FOLLOWING GRAPHICS AS ATTACHMENTS TO YOUR REPORT

A. One Power point slide depicting the overall project framework/approach/results to date
B. If appropriate, additional graphic(s) or presentation(s) depicting any key research results thus far
C. Photographs (if easy to obtain) from fieldwork to depict study information (if applicable).

IV. WEBSITE ADDRESS FOR FURTHER INFORMATION (IF APPLICABLE)

V. ADDITIONAL RELEVANT INFORMATION NOT COVERED UNDER THE ABOVE CATEGORIES.